Systematic errors and backgrounds for a Double-CHOOZ experiments

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Systematics

- global strategy:

REDESIGN THE DETECTOR TO HAVE A SMALLER NUMBER OF SYSTEMATICS

(fight one by one is hopeless)

1 LESS ACCIDENTALS → LESS CUTS

2 2 DETECTORS → "NO PHYSICAL" UNKNOWN

→ ADRESS THE REMAINING CALIBRATION ISSUES

RELATIVE NORMALISATION EXP.

SYSTEMATICS

REACTOR

- × Shape
- × POWER
- × σ / fissi-
- × BURNUP

DISTANCE

TARGET

- N_p H/C
- density
- volume

CUTS

- e^+ threshold
- n GD / H2
  - E γ GD > 6 Mev
- $e^+ - n$ time, distance

3 chooz cuts desappear

BACKGROUND

STABILITY

Systematics Errors

2 detectors is the solution for:

- Reactor
  - × Shape & FLUX
  - × burnup
- distance
  - × position of detectors
- physics of the target
  - × H/C RATIO
  - × % of GD CAPTURE
  - × SPILL IN / OUT
- physical cuts
  - × Δt $e^+ - n$
  - × E_γ CUT AFTER GD CAPTURE

2 detectors is the PROBLEM for:

- e^+ threshold → NO cut (BUFFERS)
- δe^{+-} cut → NO cut (or relaxed)

- N of protons
  - density → 0.1% short
  - volume → 0.3% " TO DECREASE *
- Kinematical CUT on E_γ from N → 0.5% for 40KeV error at 4 MeV **
  → MOVABLE N SOURCE, COSMICS n, ...
- ENERGY SCALE (local and global NON-LINEARITY) → DEFINE THE ALLOWED RANGE
  → CALIBRATION (next talk of G. MENTION)
- detector differences (geometry, optics, ..) ** *

NEUTRON

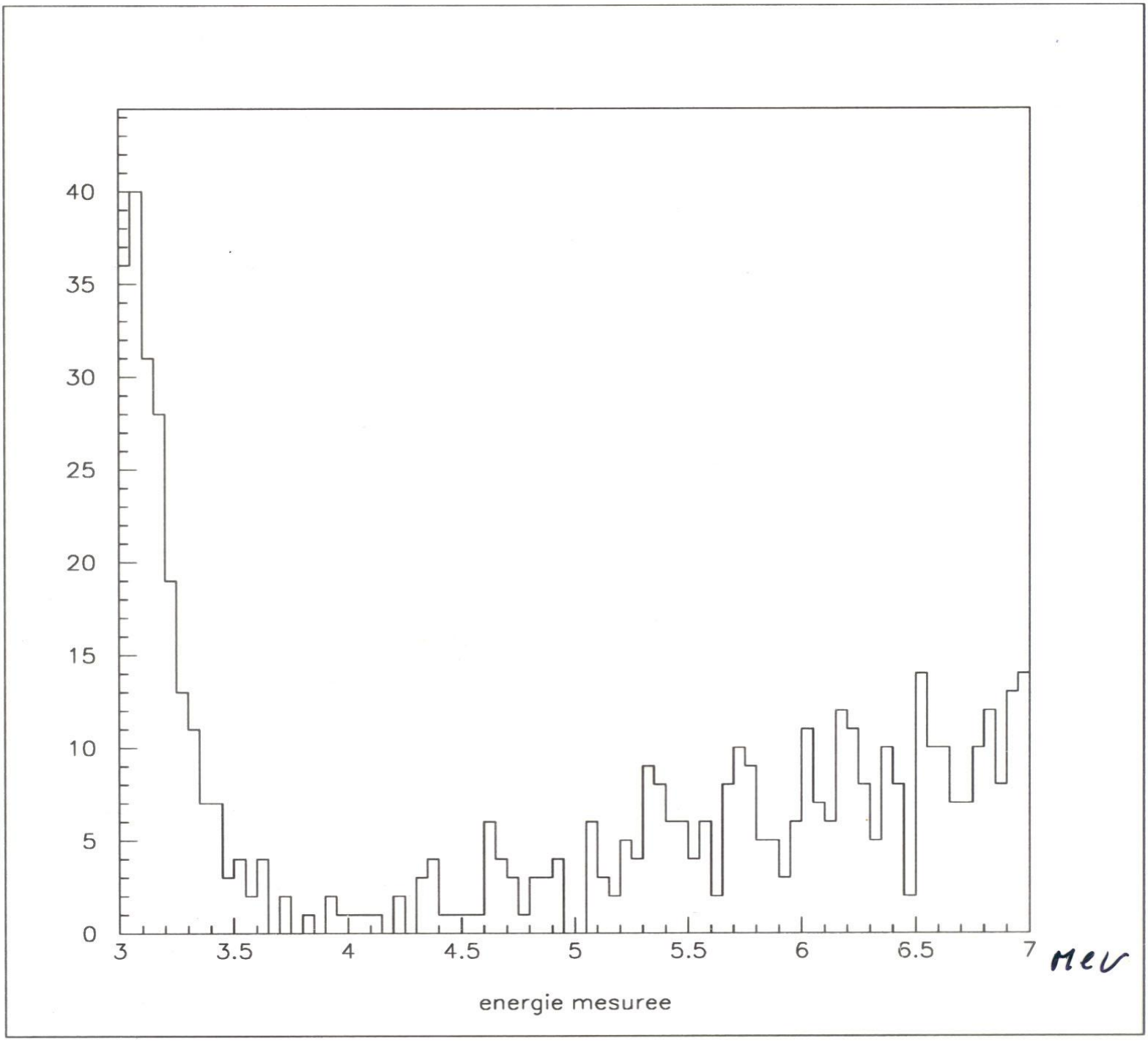
CALORIMETER THE 2.2 MeV or the GD PRODUCTS

NEUTRONICS AT THE FRONTIER OF THE TARGET

γ from n capture (all the target)

DOUBLE - CHOOZ

ZOOM



$\sim 10^4$ evts

Energy = 50 KeV

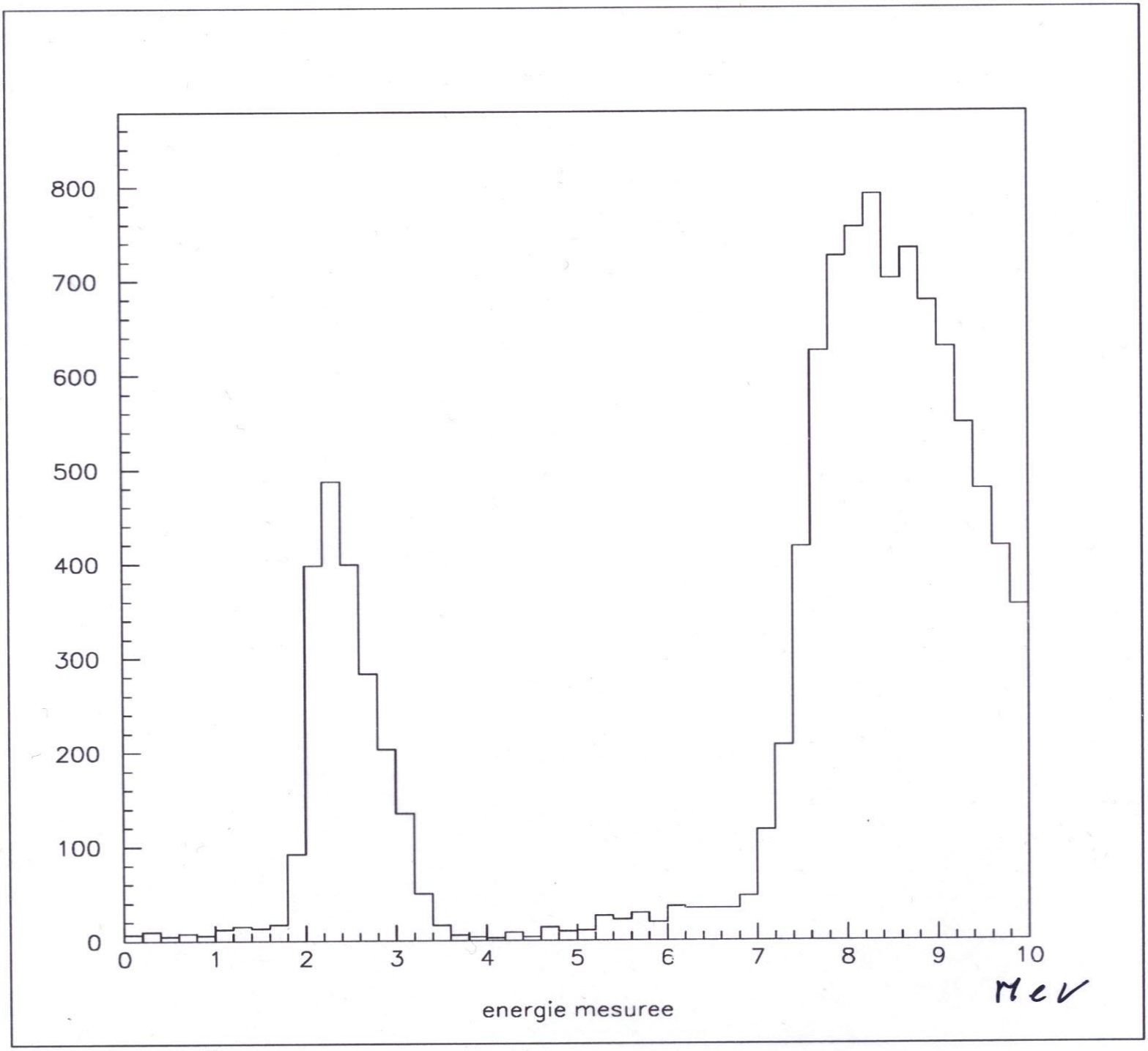
$\Rightarrow$ 0.2 %

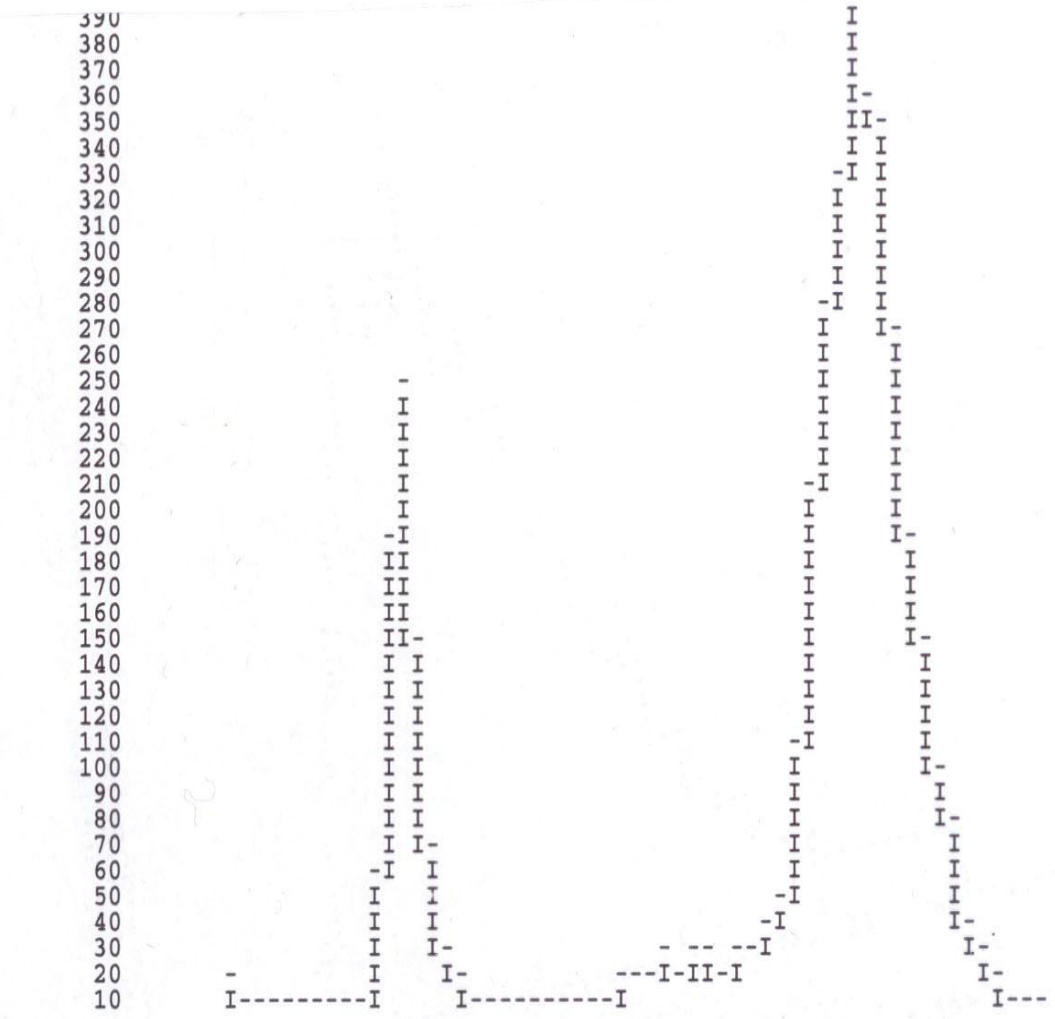
100 KeV

error between detectors

γ from n capture (all the target)

DOUBLE-CHOOZ





```
CHANNELS  10   0         1         2         3         4         5         6
           1   12345678901234567890123456789012345678901234567890123456789

CONTENTS 100               121                          12233332111
          10   1     1   6844621          1111212212234007295469407321
           1.  17327506320762482532578976053518848324611597271090675383 2

LOW-EDGE  10                                                      1111111111
           1.       1111122222333334444455555666667777788888999990000011111
           0   02468024680246802468024680246802468024680246802468024680246802468
```

14 16 MeV

```
* ENTRIES =       4000      * ALL CHANNELS =   .4000E+04      * UNDERFLOW =   .0000E+00      * OVERFLOW =   .0000E+00
* BIN WID =   .2000E+00      * MEAN VALUE   =   .7424E+01      * R . M . S =   .2673E+01
```

γ from Gd capture

NO-CALORIMETER

40 Kev error

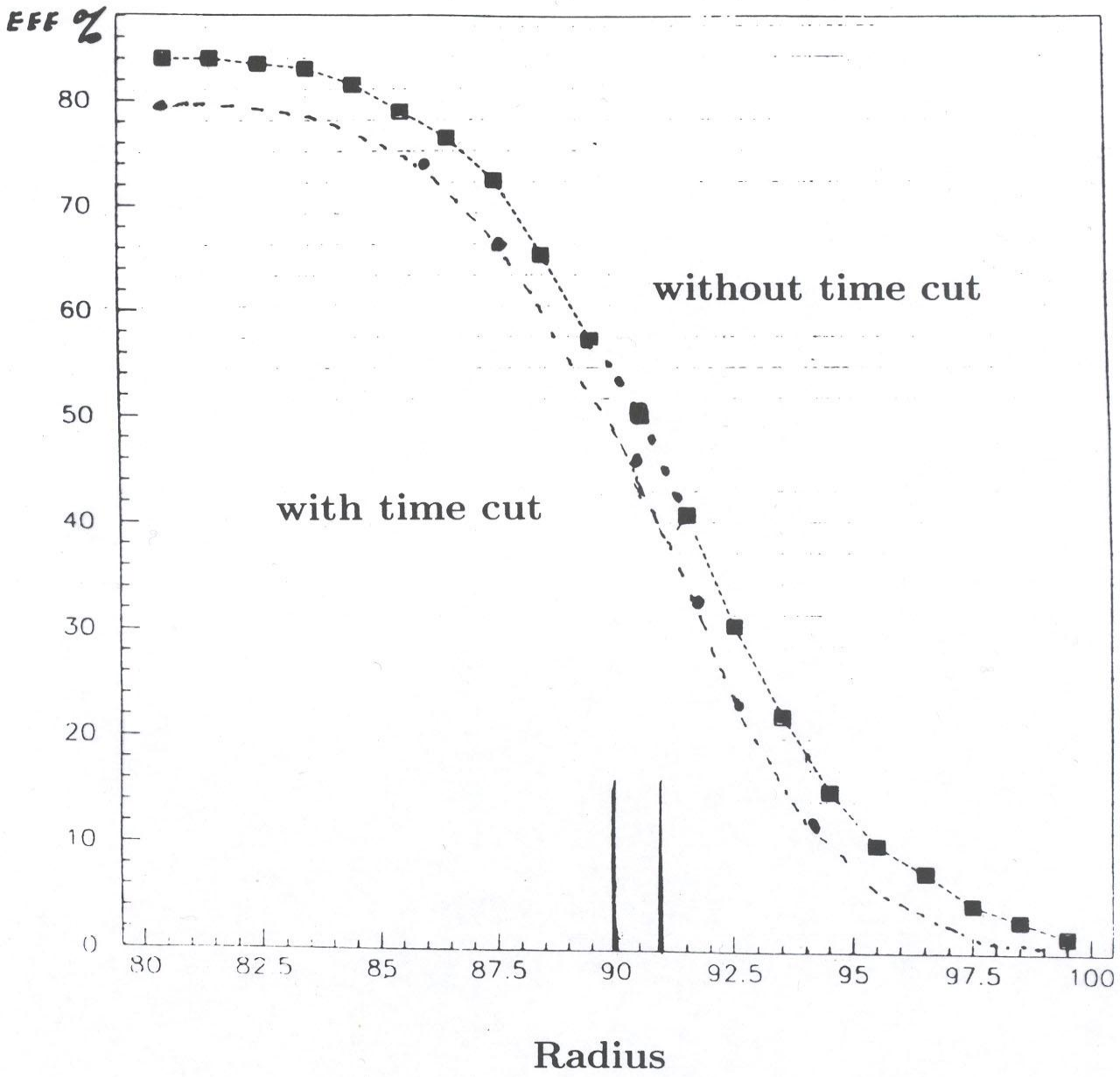
→ 0.5% at 4 Mev

→ 1% at 6 Mev

CHOOZ 1ère exp.

ν Target : Edge Effect

MC simulation

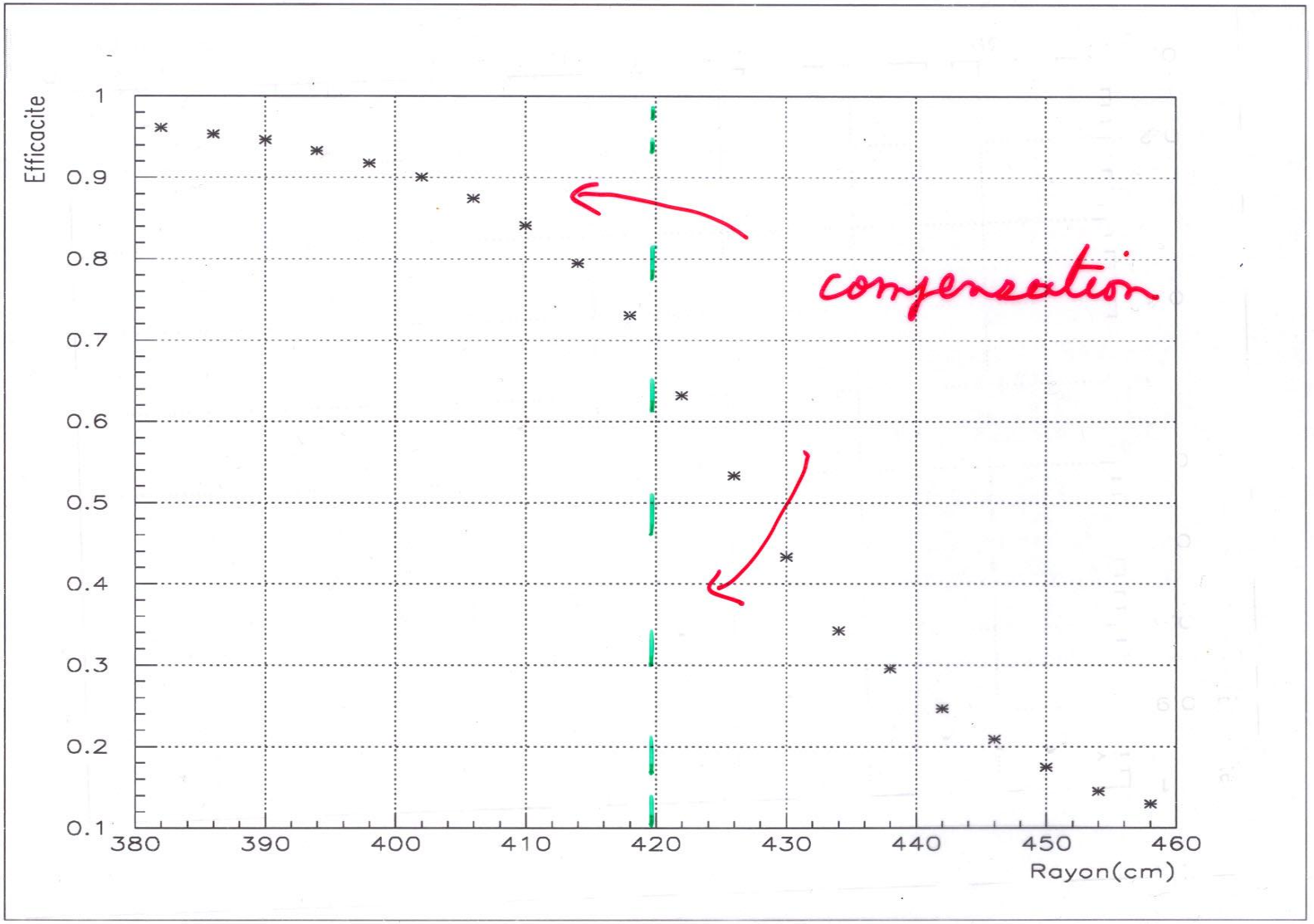


→ effet de 1% (compensation)

+ 1 mesure avec source Cf à 7.5 cm du bord
→ O.K 2

BOREXINO

Efficacité neutron seul O.DADOUN



→ Efficacité neutron dans le volume sensible (480 cm): $\epsilon_n = 72.15\% \pm 0.27\%$

→ Efficacité neutron relatif au volume cible (425 cm): $\epsilon_n \simeq 103\%$

NEUTRON CONCLUSIONS

- A SCINTILLATING BUFFER AROUND THE TARGET IS WISHED

FOR 2.2 MeV and GD PRODUCTS

- IDENTICAL DETECTORS REDUCES SEVERAL SYSTEMATICS

RATIO GD/H2

WINDOWS (FOR GD AND H2)

TIME FOR GD

AND IS HIGHLY IMPORTANT FOR THE NEUTRON EFFICIENCY AT THE FRONTIER

if not identical, same radius of curvature?

POSITRON

- THRESHOLD

EFFICIENCY AT THE FRONTIER

ENERGY MEASUREMENT

AT THE CENTER

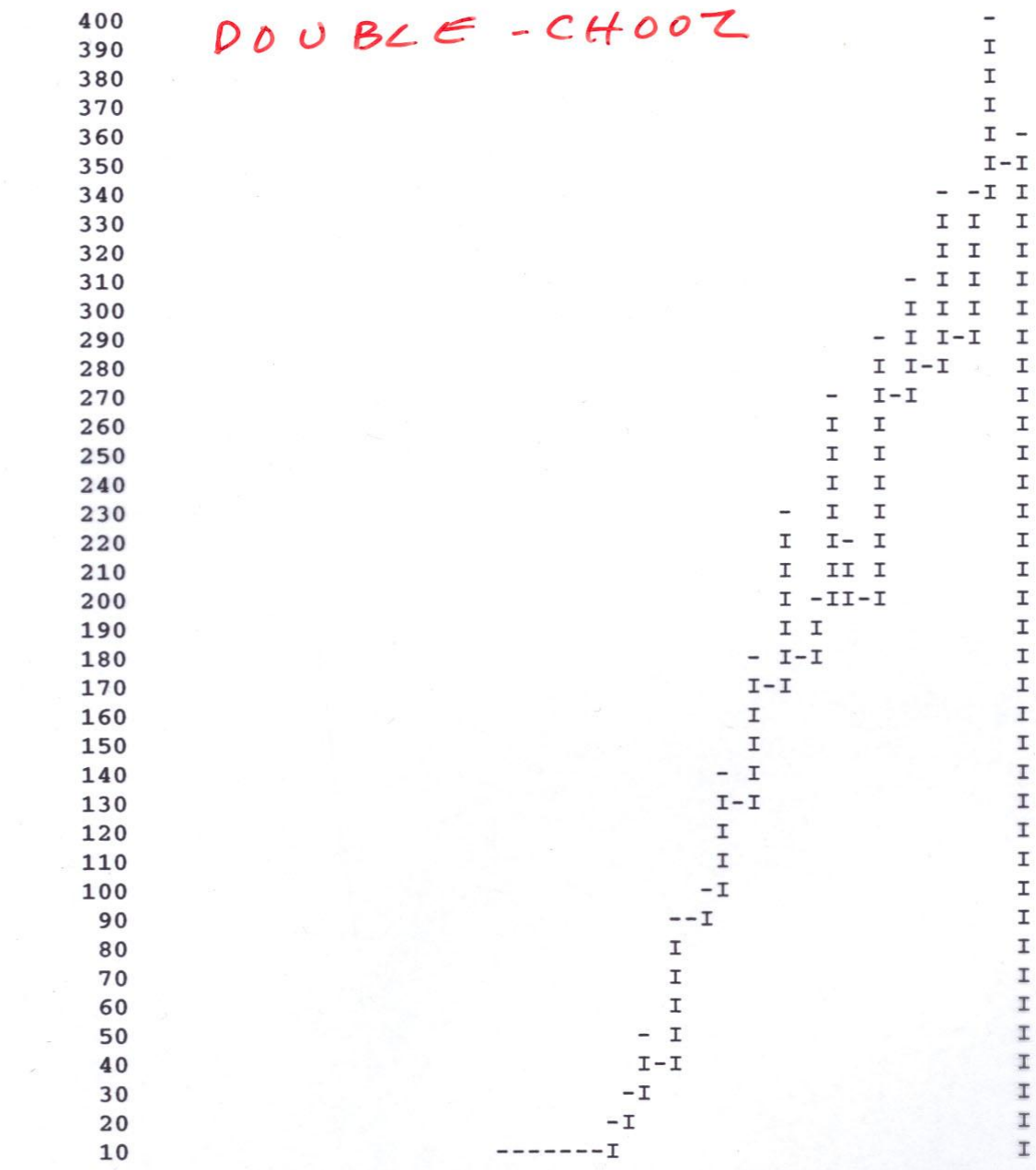
IN THE VOLUME

e^+ on all TGT
buffer 40 cm

1 energie mesuree

HBOOK ID = 711 DATE 09/11/2003
NO = 32

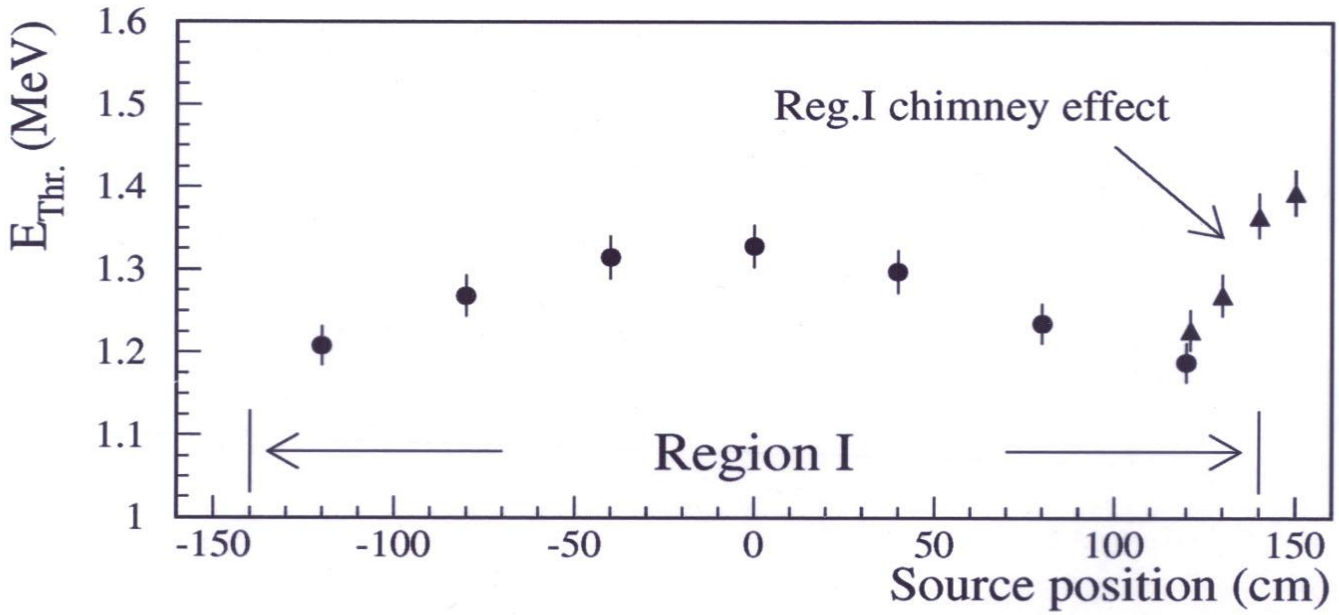
DOUBLE-CHOOZ

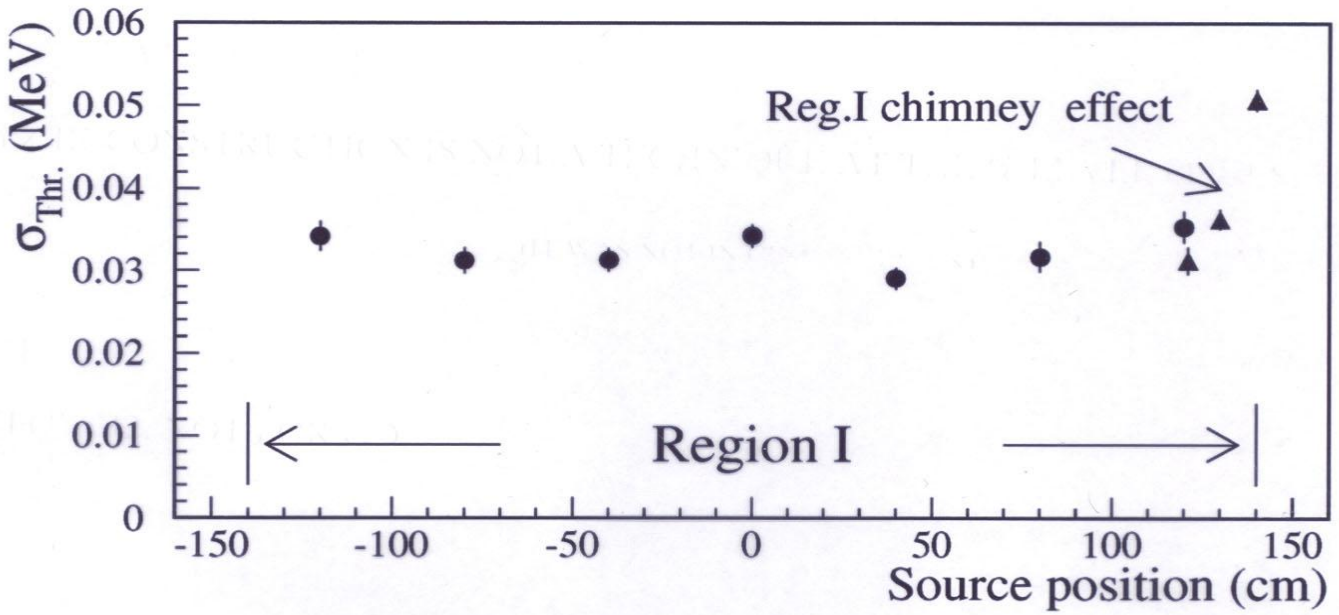


```
 CHANNELS  10    0         1         2         3         4         5
            1    12345678901234567890123456789012345678901234567890

 CONTENTS 100                                    11112112212232323333
           10                              22438893276279619861738395 5
            1.                        31324180481877235874745241033419 06

 LOW-EDGE   1.                                  11111111111111111111111 1
            0    00011222334445566677888990001122233444556667788899
            0    04826048260482604826048260482604826048260482604826
```

* ENTRIES = 40000 * ALL CHANNELS = .5465E+04 * UNDERFLOW = .0000E+00
* OVERFLOW = .3454E+05
* BIN WID = .4000E-01 * MEAN VALUE = .1622E+01 * R . M . S = .2639E+00

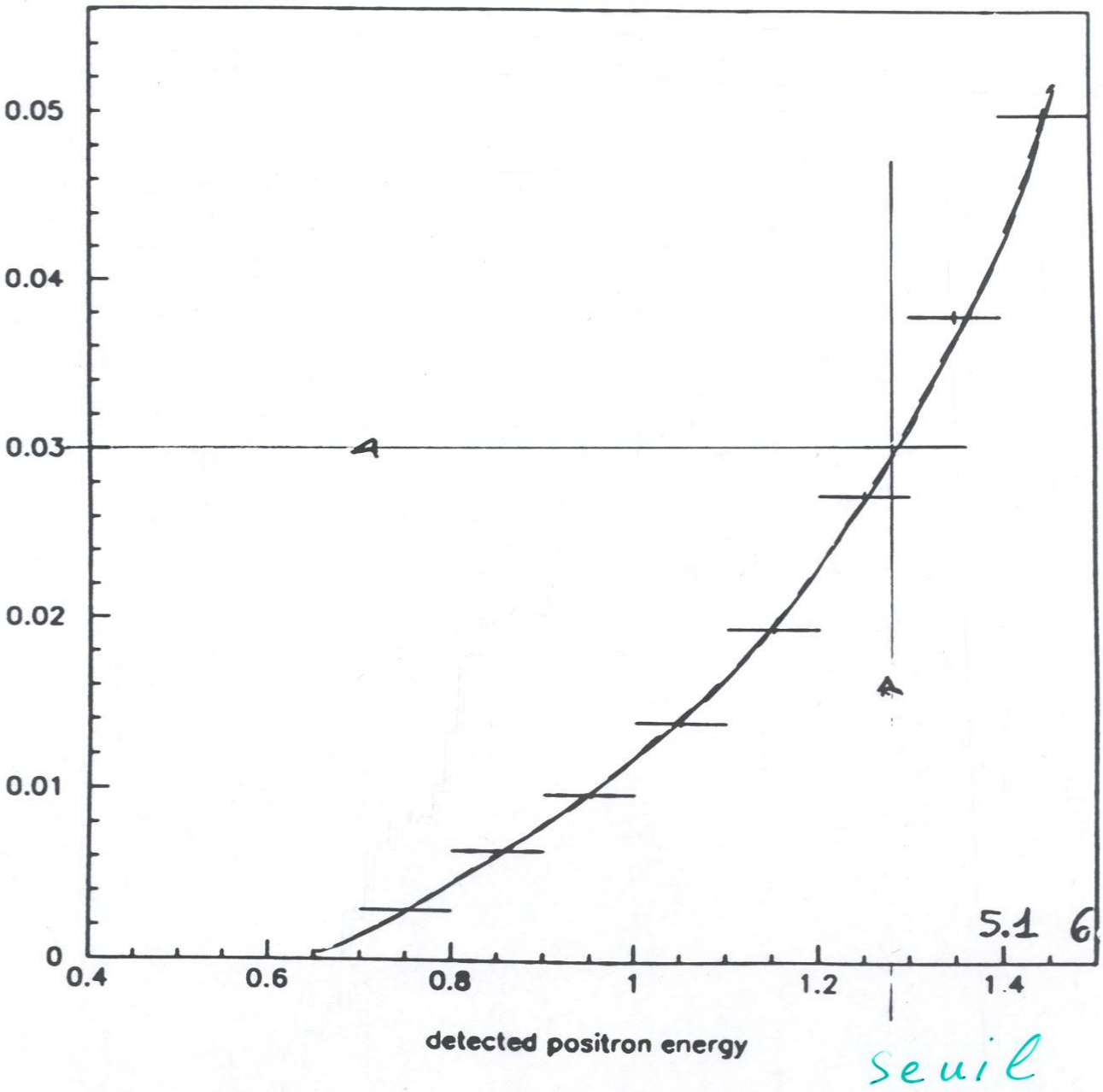
CHOOZ 1° exp.


1.6
1.5
1.4
1.3
1.2
1.1
1
$E_{Thr.}$ (MeV)
Reg.I chimney effect
Region I
-150
-100
-50
0
50
100
150
Source position (cm)


0.06
0.05
0.04
0.03
0.02
0.01
0
$\sigma_{Thr.}$ (MeV)
Reg.I chimney effect
Region I
-150
-100
-50
0
50
100
150
Source position (cm)

inefficacité positron

CH002
1ère exp.

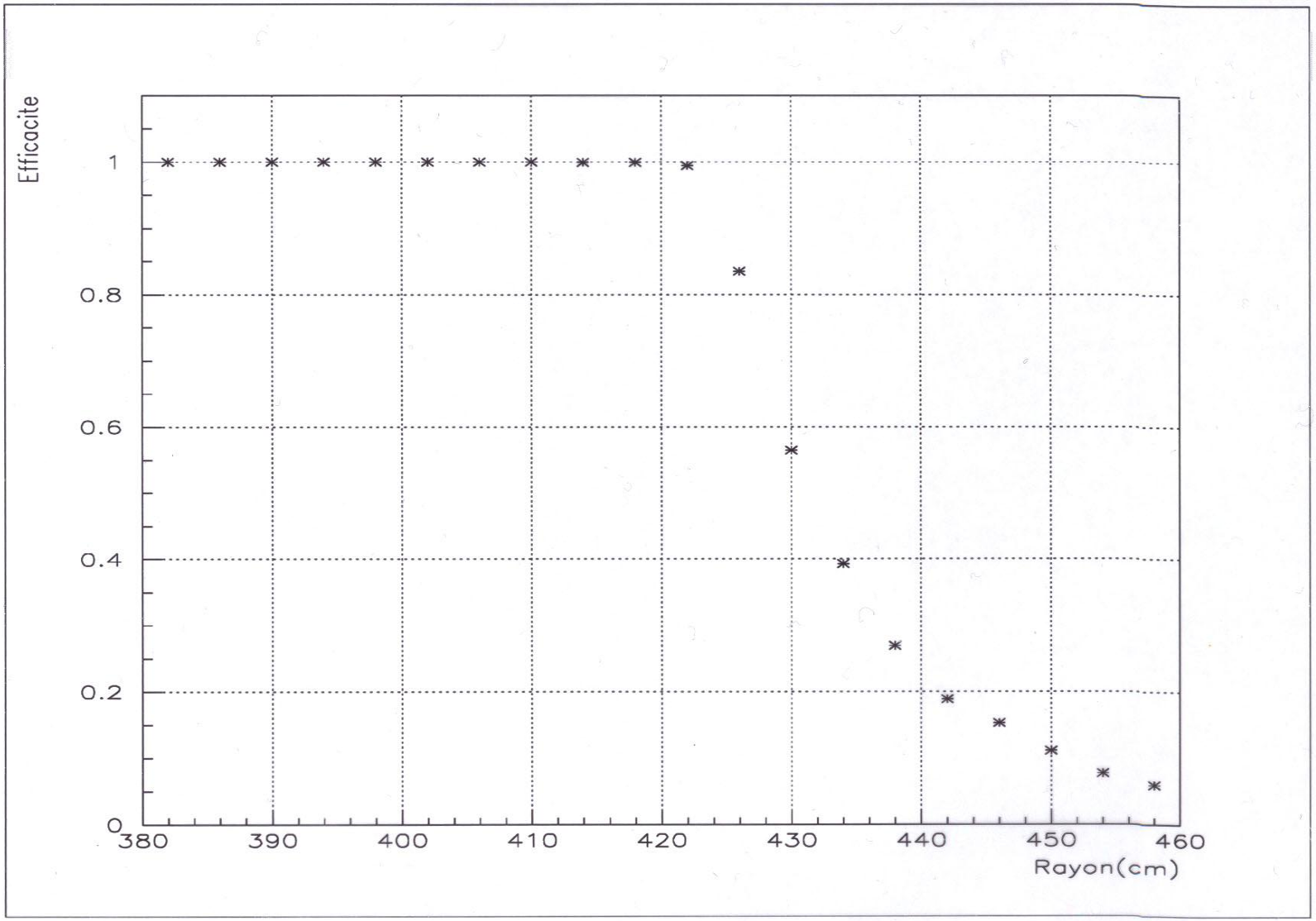


e+ efficiency

Efficacité positron seul

B X (NO BUFFER)

BOREXINO



→ Efficacité positron dans le volume sensible (480 cm): $\epsilon_{e+} = 74.97\% \pm 0.28\%$

→ Efficacité positron relatif au volume cible (425 cm): $\epsilon_{e+} \simeq 108\%$

NEUTRON- POSITRON

NO DISTANCE CUT

XYZ RECONSTRUCTION IS NOT A TECHNIQUE AT THE % LEVEL (TAILS,ETC..)

(IT WAS NOT IN CHOOZ DESIGN)

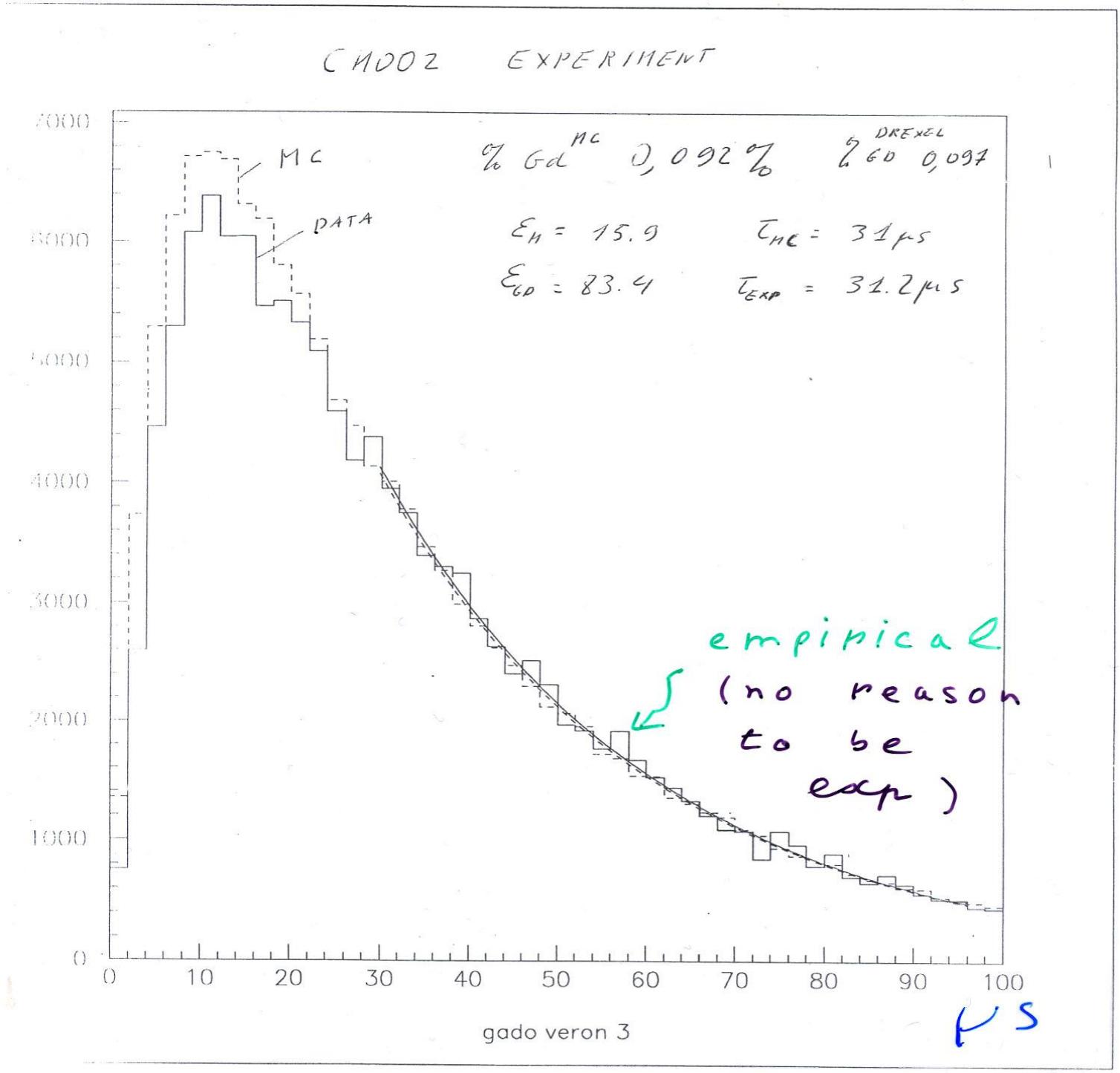
TCUT

OK FOR H2, NOT FOR GD

→ LOWER THE ACCIDENTALS

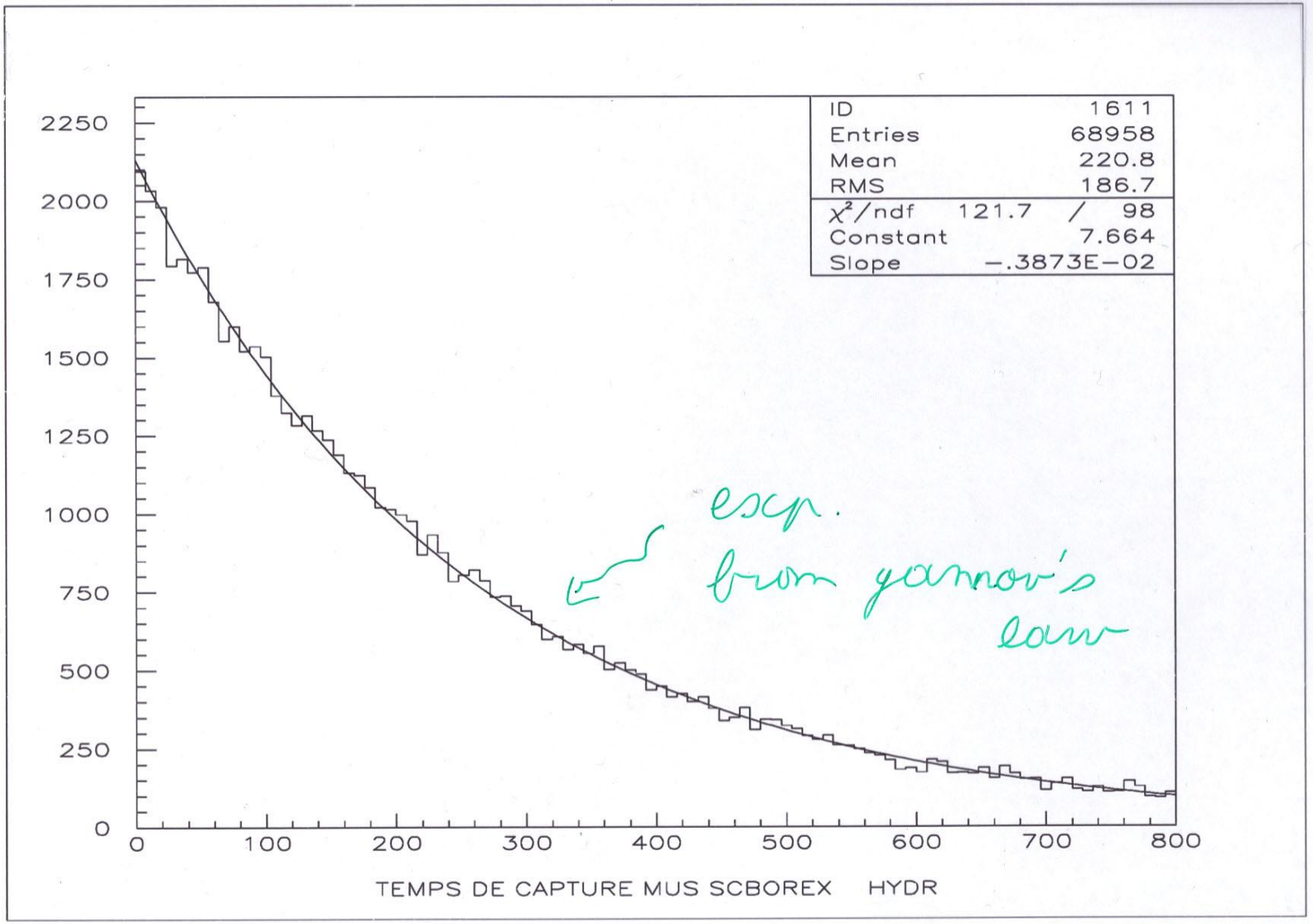
NEUTRON - MC

DATA - MC comparison for time absorption by Gd

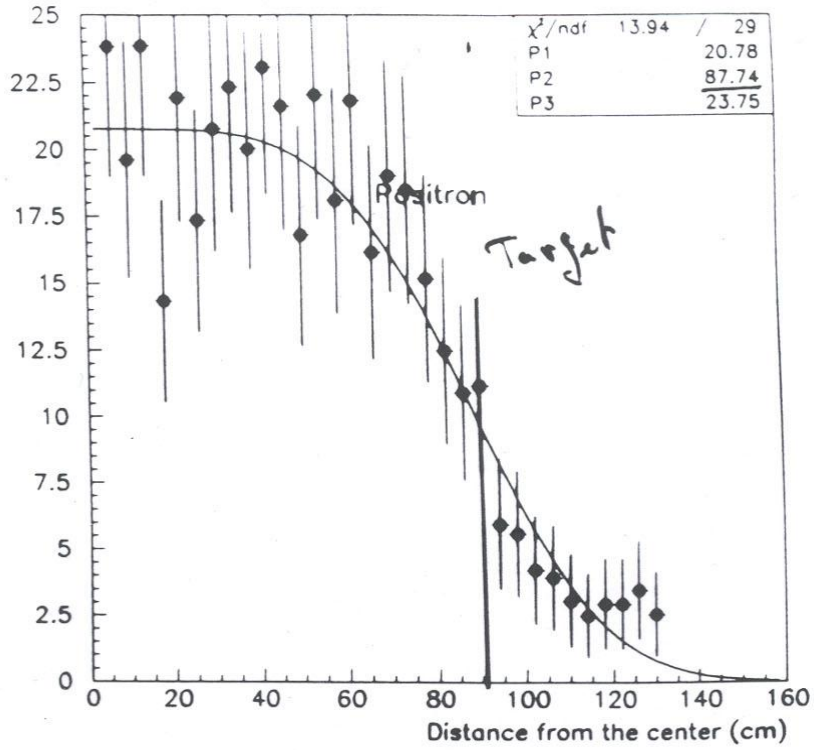


Temps de capture neutron

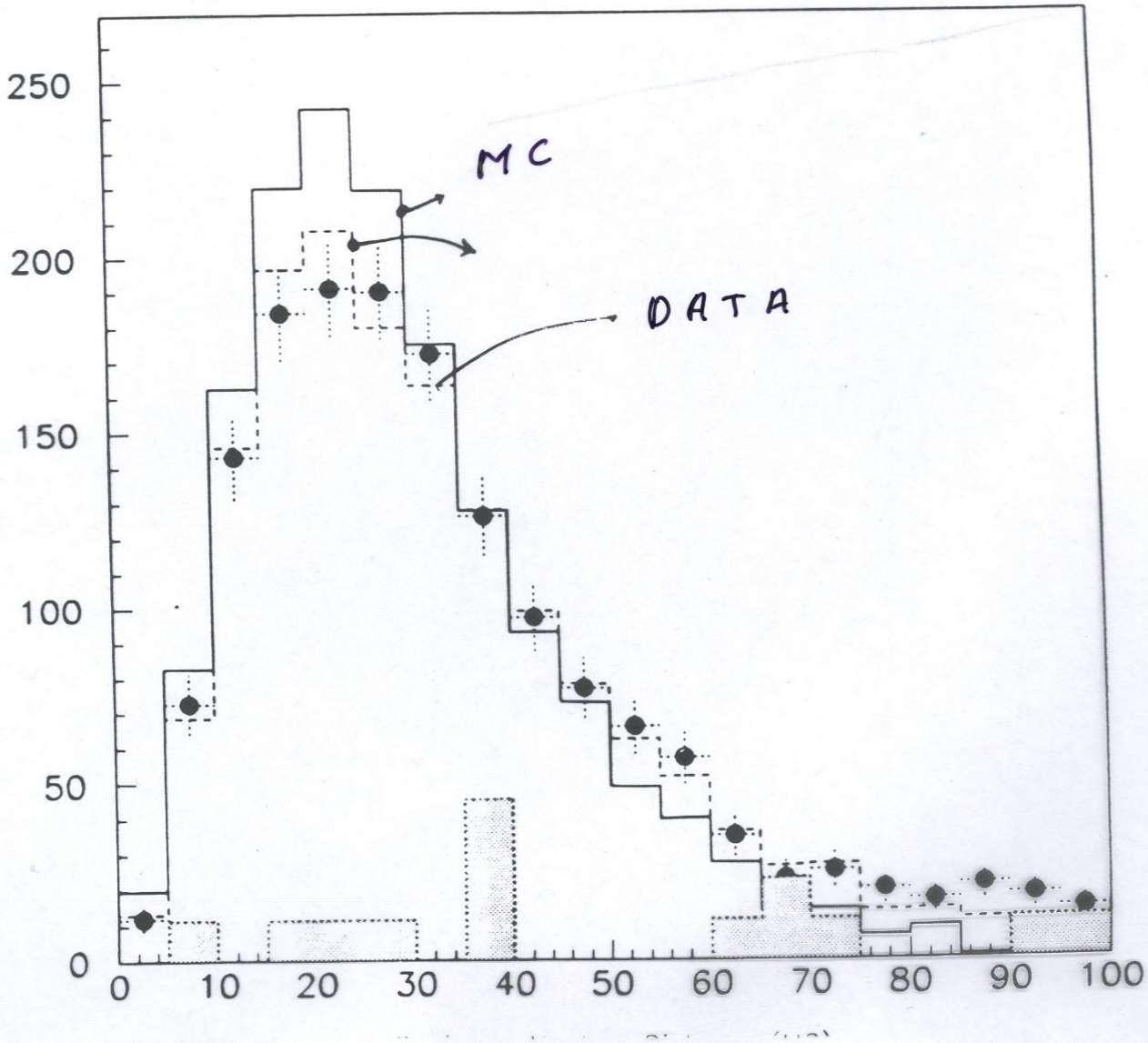
ON H2 IN Borexino



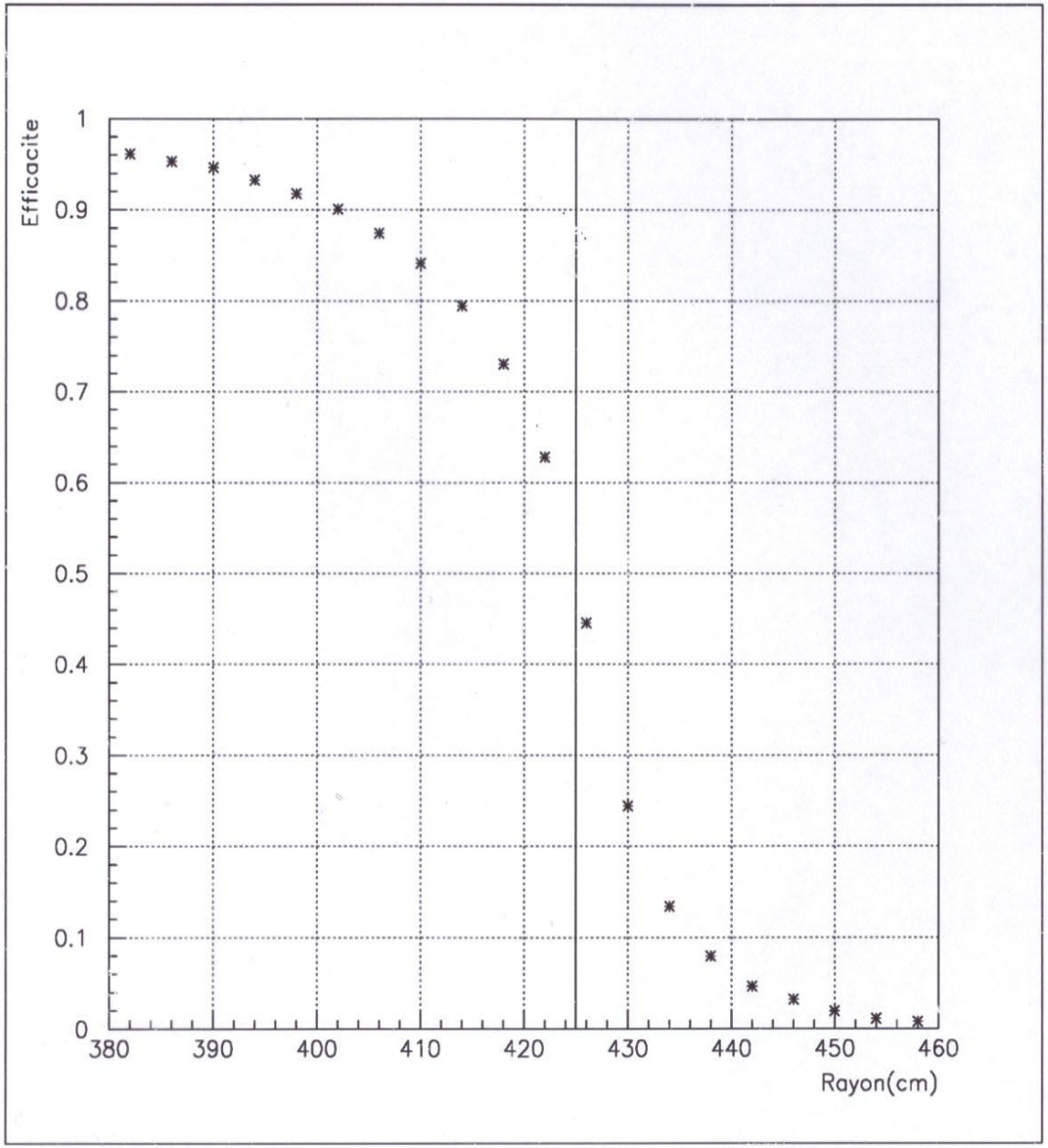
fenêtre en temps	$[1\mu s, 2\tau]$	$[1\mu s, 3\tau]$
Efficacité temps	$86.24\% \pm 0.38\%$	$94.68 \pm 0.40\%$



WITH Reconstructed Position



Les $\overline{\nu_e}$ réacteurs



B × global efficiency of $\overline{\nu_e}$ from nuclear reactors

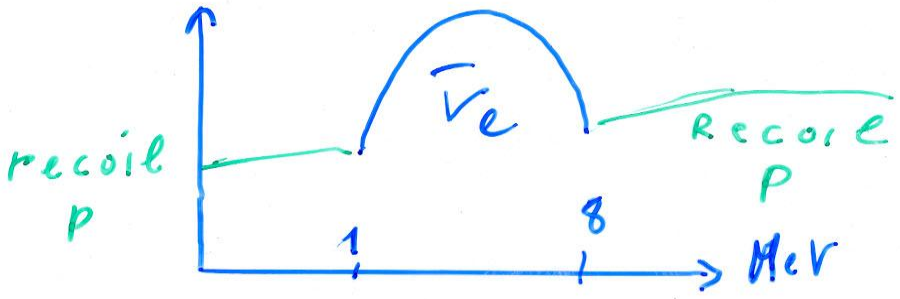
Efficacité de détection $\epsilon = 93\%$

BACKGROUND

deep link with SYS

- reduce accidentals
- " Recoil protons

→ .1/dL at 1 km (S = 50/d)



① → INTER polate

② 2 monts/y at 50%

BACKGROUND 100 m

- γ $N_\gamma \times 35$ if 20 m rocks (55 m we)
  $\sim$ 1 KHz $\rightarrow$ $\sim$ 50% dead time si cut 500 µs
  (t_{cont} = 30 µs at 0.1%)

- recoil p
  0.1/d x 50 $\rightarrow$ OK

- cosmogenique
  5/d do 20 t 150 mwe
  15/d do 10 t 50 "
  -20
  difficult to use the neutron or γ before (rates high, localisation)

- accidentals
  number of "neutron"? $\underbrace{\cdot 1}_{100}$ x 3 µs? letter buffers?

2 H "e^+" 0.1 Hz "n"

$\mathcal{L} \times \frac{1}{100}$ $\frac{}{\tau}$

BACK GROUND 1 km

- RECOIL PROTON 1/d

× buffer increased

1 m → 2 m ⇒ * 1/10 (3‰ S)

- ACCIDENTALS

* new 100 cm non scint buffer

chooz 1 cuts / $d < 30$ e^+ PM ν 3

result ⇐ now / " n-PM ν 3

relax it ⇐ $d e^+_n$ ν 8

1.3 MeV threshold

ν 300 KeV ⇐ now ??

		U^{238}	Th^{232}	K^{40}
PM	chooz	10 ppb	20	60 ppm
	LLBF (9954WB)	≤30	≤30	≤60

		Tl^{208}	K^{40}
(dpm/kg)	Sable	0.02	0.22
	acier cuivre	0.5	<5

1.85 m buffer instead of 1.0

CONCLUSIONS

3 VOLUMES DETECTOR (+VETO)

IDENTICAL DETECTORS

FOR THE NEUTRON EFFICIENCY AT THE FRONTIER OF THE DETECTOR

FOR THE LIGHT COLLECTION

IF NOT IDENTICAL, MAY BE SIMILAR ... some laboratory work to demonstrate the possibility

LOWER THE ACCIDENTAL RATE

NO D CUT

RELAX THE T CUT (FOR GD)

THRESHOLD AT 500 KeV

MEASURE TH ACCIDENTALS

NATURAL CALIBRATION POINT

NO SYSTEMATICS ON THE THRESHOLD